Solar Cell Cooling and Heat Recovery in a Concentrated Photovoltaic System

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Abstract

Concentrated photovoltaic systems with high efficiency solar cells are being widely investigated, aiming at improving the cost-efficiency balance in the solar energy field. Different cell types are in use: e.g., high concentration triple junction cells, reaching efficiencies of the order of 35 - 40 % at 1000 suns, and medium concentration mono-crystalline silicon cells, with efficiencies of the order of 20 - 25 % at about 100 suns. While the higher efficiency of triple junction cells seems extremely promising, the very demanding requirements imposed by high concentration levels in terms of sun tracking precision make the convenience of one system with respect to the other still uncertain.
In both cases, an important issue is given by cell cooling, as the cell efficiency and stability typically decreases with temperature (especially in the case of silicon). At high concentrations, very large heat fluxes are present (about 100 W/cm^2 at 1000 suns), requiring quite efficient cooling methods in order to keep the cell temperature at reasonable values. On the other hand, the extracted heat can be recovered for cogeneration purposes, at least in cases where the system is installed in the proximity of residential buildings or industrial plants. In the present application, COMSOL has been used to simulate the full 3D system provided by a solar cell coupled to different versions of a micro heat exchanger. The analysis includes both fluid dynamics (laminar regime) and heat transfer effects, also considering the thin insulating layers provided by the dielectric materials in the cell packaging. One of the micro channel systems used in this application is shown in Figure 1, with a simple geometry inspired to the pioneering reference [1].

Reference

1. D. B. Tuckermann and R. F. W. Pease, “High-performance heat sinking for VLSI”, IEEE Electron Device Lett. 2, 126 (1981).

Figures used in the abstract

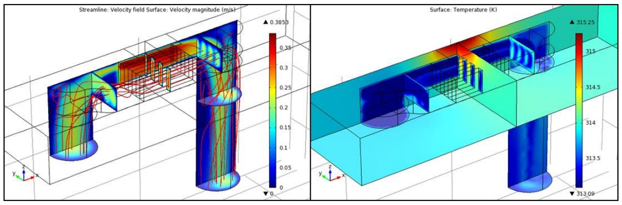

Figure 1: Velocity field and temperature distribution in a micro channel (rectangular cross section) heat exchanger. The geometry is cut along a symmetry plane.